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ABSTRACT

This paper reports on a study that sought to determine the relationships between investment in education and training and performance in production, quality, and safety in manufacturing companies in northeast Alabama and northwest Georgia. The study also examined whether company size was a factor in predicting the ratio of the investment. One hundred and eight questionnaires from manufacturing companies with 50 or more employees were included in the study. These questionnaires supplied information about the companies; how the companies performed in production, quality, and safety; and the investment in education and training. The study confirmed the findings of the literature survey that not enough attention has been paid to the financial accountability of the education and training functions with manufacturing concerns. Results also supported the conclusion that there had been little systematic effort in neither the manufacturing industry nor academia to generate and gather empirical evidence concerning the veracity of the evaluation process and the contribution of education and training to the bottom line in manufacturing companies. Consequently, there appears to be a lack of understanding and appreciation for the contribution of education and training to business success. (Contains 28 references.) (DFR)

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Impact of Investment in Education and Training

on Performance in Production,

Quality and Safety

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Abstract

The purposes of this study were: (a) to determine the relationships between investment in education and training and performance in production, quality and safety in manufacturing companies in northeast Alabama and northwest Georgia; and (b) to determine if company size was a factor in predicting the ratio of the investment.

The population for the study included manufacturing companies with 50 or more employees in 14 counties in northeast Alabama and 9 counties in northwest Georgia. The survey was sent to 250 top managers of manufacturing companies selected at random in these regions. Questionnaires were designed to determine: (a) the company profile; (b) how companies performed in production, quality and safety; and (c) investment in education and training. One hundred and eight useable questionnaires were returned for a return rate of 43%. Regression analysis was used to answer the first research question and multi-variate analysis was used to answer the second research question. For the regression analysis, seven independent variables were selected from the investment in education and training category and these were regressed

against selected dependent variables from each of the other categories studied.

The study confirmed the findings of the literature survey that not enough attention has been paid to the financial accountability of the education and training functions within manufacturing concerns. The results also support the conclusion that there has been little systematic effort in either the manufacturing industry or academia to generate and gather empirical evidence concerning the veracity of the evaluation process and the contribution of education and training to the bottom line in manufacturing companies. There appeared to be a lack of understanding and appreciation for the contribution of education and training to business success.

Rationale for the Study

Increasing globalization of trade and technological changes in production processes have transformed the manufacturing industry in recent years (Dertouzos, Lester, & Solow, 1990). This increasing globalization has forced manufacturing companies to incorporate a philosophy of total quality management (TQM) and continuous improvement in all functions and processes to be competitive in the global market place (Deming, 1986). Technological changes, which include both technical and managerial aspects, have resulted in an unprecedented reduction in the time required for product design, product development, set-up for manufacturing, and production.

The implications of this globalization process upon the education and training function are substantial. Employers can be expected to increase their employment standards to require all managers, engineers and technologists to have a four-year degree, technicians, an associate degree, and line workers a high school diploma (Babcock, 1991). Companies will need to provide

training on interpersonal relations, communications, computer skills, and the corporate culture itself in order for these employees to function and manage effectively in an increasingly chaotic environment (Peters, 1987). Simply training workers in the skills needed to produce the products is no longer sufficient for competitiveness.

Statement of the Problem

The functions of education and training often fail to present a meaningful and quantitative picture that managers can relate to return on investment (ROI). Educators and trainers frequently resort to reciting nebulous reassurances of the value of the education and training because there has been little success in relating these to ROI in a meaningful way. This inability to relate education and training to ROI stems to a large extent from the mis-perceptions that industrial managers have of these functions (Jackson, 1989; Murphy,1997).

Purpose and significance

The purpose of this study was to gain insight into the relationships between investment in education and training and performance in production, quality, and safety in manufacturing companies in northeast Alabama and northwest Georgia. Little empirical research has been conducted to date on ROI in education and training, although books, articles and workshops have become plentiful in recent years.

The need for meaningful evaluation that can relate training to ROI is a primary concern for people charged with developing programs in industrial settings (Hawthorne, 1987; Murphy, 1997). Corporate education and training are vulnerable when it comes to competing for sometimes scarce resources, thereby creating a need for meaningful evaluation of education and

training upon which to base corporate policy decisions about the allocation of resources (Hawthorne, 1987). If it can be shown that there is a significant relationship between investment in education and training and performance, the results can be used to propose to top management that there is probably also a relationship between education and training and increased productivity, better quality, fewer illnesses and injuries, and more profitability. Such findings may indicate that there are indeed certain advantages to be gained in terms of corporate dollars spent and improved productivity, quality, safety, the work environment, and worker morale by investing in education and training, and that procedures and techniques for relating training dollars to ROI should be developed.

Research Questions

The primary purpose of this study was to answer the following research questions:

1. Is there a relationship between corporate investment in education and training and performance in productivity, quality, and safety in manufacturing companies in northeast Alabama and Northwest Georgia?
2. Is there a difference in the investment in education and training between small companies, with 50 to 99 employees, medium-sized companies with 100 to 225 employees, and large companies, with 226-1200 employees?

Limitations

This was a local study limited to manufacturing companies in 14 counties in northeast Alabama and 9 counties in northwest Georgia. The study was limited to companies with greater than 50 employees and was a top-down study. Only top managers, i.e., company presidents, plant

managers, chief executive officers, chief-operating officers, vice presidents, and directors, were contacted and responded. There was no attempt to survey rank and file, direct labor, or first line supervisors.

Assumptions

Assumptions made regarding this study are enumerated below. These assumptions should be taken into account when making generalizations to the manufacturing industry in other areas of the southeast or the country as a whole.

1. It was assumed that the responses were honest and accurate.

2. This study looked only at manufacturing companies.

3. It only looked at the training effect on the human aspect of production.

4. Measurement criteria were simplified, using only three factors of productivity: sales dollars per employee, inventory turnover rate, and return on investment.

5. Performance in quality considered ISO 9000 certification, the rate of quality rejects at final inspection, and customer return rate for product defects.

6. Safety performance considered illness/injury rates and lost workday rates, both factors mandated by the Occupational Safety and Health Act, and the number of workers compensation cases the company experienced during the most recent reporting period.

Review of the Literature

Constant change is always a factor with which one must be concerned in the field of manufacturing. Because change is usually rooted in the past, a knowledge of the history and developments in the subject of corporate education and training is necessary to help gain a

perspective of what has happened in the field and help to grasp where it may be going. The years from 1945 to around 1965 were considered to be the golden era of industry. The demand for goods and services from war-torn areas of the world was high and was matched by a high level of productivity in American industry. American industry had not suffered the war damage that most of the rest of the industrialized world had suffered, thereby leaving the industrial base of the United States completely intact. There was little competition for American manufacturers, and demand for goods was high and the concern for quality low. Success under these conditions was virtually assured (Dertouzos et al., 1990; Thurow, 1992).

However, the years between 1966 and 1989 were turbulent for American manufacturers. During this period, the former war-torn regions of the world, primarily the consumer nations of Europe and Japan, had rebuilt their industry and infrastructure to such an extent that global competition became a major issue. Industries in the United States, who had long neglected quality and productivity, were slow to accept the fact that foreign competitors had developed the capability to produce goods of a high enough quality to challenge American goods in the market place. They were quick to blame countries like Japan of playing unfair through low wages and the process of *dumping*, in which goods were dumped on the market at or below cost (Dertouzos et al., 1990).

Developments within the manufacturing industry that took place beginning about 1969 and continuing through the 1990s catapulted the importance of training and education to the forefront of industrial management concerns. Three factors provided the impetus for this trend: (a) global competition, (b) advances in technology, and (c) internal competition between

organizational departments for the allocation of funds needed to maintain the leading edge. These events accelerated the pace at which new knowledge and skills must be assimilated. The pace has accelerated to the point that what used to take an entire year to bring about now occurs in about a fiscal quarter (Atkinson, 1999). The life span of many products, particularly electronics, is about two years (Tapscott, 1997).

Operations in an information-based industry can take place successfully only within an organizational structure and an atmosphere that encourages initiative, innovation, creativity, and flexibility (Gayeski & Stalovitch, 1999). The prescription for this type of environment is flatter organizations with fewer levels of hierarchy in the corporate organization, encouraging employee empowerment (Ross, 1991). Fundamental to the strategic HRM perspective is an assumption that a firm's performance is influenced by the set of HRM practices they have in place. A strategic approach to HRM involves designing and implementing a set of internally consistent polices and practices that ensure a firm's human capital contributes to the achievement of its business objectives.

Trends in Manufacturing

One of the primary responsibilities of manufacturing and training managers is to be aware of and react to trends in the industry. These managers must also be aware of what drives these trends and understand the issues and the potential impact they can have on the organization. A survey of manufacturing identified 10 manufacturing trends that dominate the industry. These were: (a) automation and information management, (b) flexible manufacturing, (c) supply-chain management, (d) outsourcing, (e) work teams and employee training, (f) cross training and

flexible job assignment, (g) hazard operations (HAZOPS), (h) consolidation and downsizing, (i) competitive costs and pressures, and (j) ISO 9000-certification (Morris, 1997). This rather broad listing of manufacturing trends can be subsumed under categories as automation, internal and vertical external integration, flexibility in manufacturing, and worker assignment, job and function reorganization, outsourcing and supply chain management, hazard identification and control, global marketing, and total quality management (TQM). These can be quickly summed up as the management of technology and human capital. Implicit in all of these is the critical nature of corporate training.

Trends in Training

Bassi, Benson, and Cheney (1996) reported ten trends that were identified by the National Skills Standard Board of the National Center on Education and the Economy in Washington D.C. that will affect industry. These were (ASTD, 1997):

1. Skill requirements will continue to increase in response to rapid technological change.
2. The American workforce will be significantly more educated and more diverse.
3. Corporate restructuring will continue to reshape the business environment.
4. Corporate training departments will change dramatically in size and composition.
5. Advances in technology will revolutionize the way training is delivered.
6. Training departments will find new ways to deliver services.
7. Training professionals will focus more on interventions in performance improvement.
8. Integrated high-performance work systems will proliferate.
9. Companies will transform into learning organizations.

10. Organizational emphasis on human performance management will accelerate.

Success in the new global is, to a large extent based on an understanding of the implications of these trends.

Performance Measurement Indices

Several ratios are frequently used as indices to evaluate a company's performance in production, particularly return on investment (ROI), sales per employee and the average number of inventory turns per year (L. Barnard, personal communication, October 20, 1996). However, there are some problems with the latter two ratios, sales per employee and average inventory turnover, as they are very difficult to specify since they tend to be product and industry sensitive. For example, it makes no sense to compare razor blades that cost cents or fractions of cents per blade with Mercedes Benz cars that cost tens of thousands of dollars each to calculate sales per employee or inventory turnover rates, as they are not based on a common denominator. Ratios that would be unacceptable for the Bic Razor Company for example, would be an acceptable ratio for the Boeing Aircraft Company (C. Wycoff, personal communication, April 26, 2000).

Three indicators of quality performance generally accepted within the manufacturing industry are ISO-9000 certification, rate of rejects at final inspection, and customer return rate (L. Barnard, personal communication, October 20,1996). There are just over 400,000 manufacturing establishments in the United States (Best, 2000). While not a direct indicator of quality performance, ISO-9000 certification is an indicator that a company is pursuing excellence in quality, both with regard to the product it produces and the process it uses to produce it. ISO-9000 certification is further evidence that both the product and the process are imbedded in a

corporate structure and corporate culture that are committed to excellence in all of its policies, procedures and operations (Peach,1994).

A more concrete measure of quality, on the other hand, is the number of product rejects at final inspection and the number of customer returns. The number of product rejects at final inspection, in particular, is a direct indication of how well the manufacturing and management process are working. Quality cannot be inspected into a product but must be manufactured into the product during the fabrication process, and high rejection rates at final inspection is an indicator that the process requires adjustment. Under TQM and ISO-9000 criteria, defects in the process reflected in the reject rate at final inspection are not limited to the fabrication process alone, but extend to the whole of manufacturing operations, corporate structure, corporate culture and management (Gitlow & Gitlow, 1987; Peach 1994). Prior to the introduction of TQM into the American manufacturing process during the early 1980's, and the widespread adoption of this approach, the quality of products and services was primarily cost driven. Under this cost driven approach, companies typically kept large numbers of field service representatives in place to take care of quality problems and shore up customer relations after quality problems had surfaced. In order to successfully compete in the global market place, however, these manufacturers began to shift the focus of product quality from a primarily cost driven basis, to the satisfaction of the customer.

Safety statistics, unlike production and quality statistics, are relatively easy to acquire due to the fact that law and regulation mandate them, and there are only a few sources with which a researcher must communicate. OSHA, for example, requires each business establishment with ten

or more employees to keep illness, injury and lost workday (LWD) statistics. Although OSHA does not keep or require statistics on workers compensation, these are available indirectly through LWD statistics. Injuries resulting in three or more lost workdays are classified as falling within workers compensation parameters (T. Perry, personal communication, April 26, 2000). Individual states also keep raw data on the number of worker's compensation cases but these are difficult to reliably convert to percentages.

Illness and injury incident rates in manufacturing were all sensitive to company size. OSHA divided company size into categories according to the number of employees. Company size categories and illness/injury incident rates corresponding approximately to those used in this study were (a) 50-249 employees-9.7, (b) 250-999-10.9 and(c)over1000-10.1. All of the above data were for 1996, the latest available from OSHA and the Bureau of Labor Statistics (BLS, 1998).

Evaluating Performance: The Effect of Training on Return on Investment

The picture that emerged from the literature revealed a corporate training profession that had been successful in cloistering itself within the organization, isolating itself from the strategic planning process and divorcing itself from the bottom line. Training professionals, aided and abetted by organizational managers at all levels, had succeeded in creating a sub-culture within the organization which was inviolable. This sub-culture, which existed unchallenged until the late 1980's, was one in which management tacitly agreed to support training, fund courses, bring in speakers, hold seminars and refrain from objectively evaluating training results. As part of this tacit agreement, management gave moral support to training, gave key-note speeches, introduced

big-name speakers, and participated in award ceremonies. In return, training tacitly agreed not to pester management. The result of this tacit arrangement was to limit training's access to top management and to isolate it from the strategic planning process (Murphy, 1997; Phillips, 1997). This resulted in the fragmentation of the training function from the rest of organizational operations and meant those providing the training function became the ones who decided what should be taught. If evaluation was used at all, it was usually limited to the first level, which Kirkpatrick (1994) described as the reaction of the trainees to the training. Murphy (1997) captured the situation that had existed in training for several decades in his remarks:

> Since we [training practitioners] can't get direct access to top executives to question them about strategic direction, our course offerings are based on questionnaires and interviews with prospective trainees—which means that ultimately we're the ones who decide what everyone ought to learn. Consequently, programs are evaluated more by participant ratings than by any measurements of business impact. Executives are not expected to invest themselves personally in the process, beyond showing up for opening benedictions and closing cocktails. (p. 4)

The silence within corporate structures has survived because it met the requirement of fulfilling top management's need to appear to be developing effective managers. Chief executive officers needed to provide evidence to their boards of directors that they were preparing for the future, and what better way to demonstrate this than to show a massive education and training effort. Both managers and trainers had a stake in showing the board of directors that education and training was effective in developing effective managers, and that they were not resting on

their laurels. For years, education and training practitioners had been able to convince top management that training results could not be measured to the extent top management would like it to be (Murphy, 1997; Phillips, 1997).

Training Evaluation Models

Although there are several training evaluation models in existence, most are adaptations of Kirkpatrick's (1994) four level model. Within his model he listed four levels necessary to the effective evaluation of training. These four levels included (a) Level 1-reaction, (b) Level 2-learning, (c) Level 3-behavior and (d) Level 4-results. The first level referred to how the participant reacted to the training, i.e., trainee satisfaction, and was instrumental in determining whether the training would be continued. The second level referred to the extent of change or improvement in participant attitudes, knowledge or skills. The third level referred to the extent to which behavior was changed. The fourth level referred to measurable factors such as increased production, improved quality, decreased costs and the reduced frequency and severity of accidents (Kirkpatrick, 1994).

Calculating Return On Investment (ROI)

Using Kirkpatrick's (1994) model, Phillips (1997) added a fifth level of evaluation which he calls the calculation of return on investment (ROI). According to Phillips, although there are many different methods and approaches to calculating ROI, to be effective from a training and human resource development standpoint, these must be rooted in a corporate strategy that includes the impact of programs to be measured on organizational mission, organizational change and long term profitability (Phillips,1997). The ROI process must be applicable with all types of data,

including hard data, typically represented as output, quality, costs and time, and soft data, which includes job satisfaction, absenteeism, turn over, grievance and complaints. All these are costs that must be accounted for. The ROI process must include the costs of the program, the ultimate level of evaluation and a comparison of costs to benefits (Phillips, 1998a).

Phillips(1997) presented a typical method for calculating ROI that takes each of these factors into account. The method he presented included the following steps:

1. Define the purpose of the evaluation
2. Determine the evaluation levels
3. Determine the timing of the evaluation
4. Develop evaluation instruments
5. Collect the data
6. Isolate the effects of the training
7. Convert the data into monetary values
8. Tabulate the program costs
9. Identify the tangible and intangible benefits
10. Calculate the return on investment

Planning for the collection of the data should include a consideration of the purpose of the evaluation, the depth or level to which training results are to be measured and, development of the evaluation instrument. Integral to this process is the timing of the evaluation, which can be very important in determining the value of any benefits which are expected to accrue over time.

The ROI process must be adaptable and appropriate for use with a variety of programs.

Some models are deficient as they are limited to certain areas, such as productivity or sales training, where hard data is readily available. In many situations, an estimate of the ROI is also required before the actual program is developed and the ROI process must include the costs of the program, ultimately comparing the benefits with the costs. The ROI process must also show a successful track record over a wide range of applications (Phillips, 1998a).

Phillips (1998a) concluded by recommending a cost/benefit ratio (BCR) computed from program benefits and costs. The data was then reduced to the following formula:

$$BCR = \frac{\text{Program Benefits}}{\text{Program Costs}}$$

Finally, ROI uses a ratio of net benefits to program costs, which is the same formula used in other programs to estimate ROI:

$$ROI\,(\%) = \frac{\text{Net Program Benefits}}{\text{Program Costs}} \times 100$$

Ideally, there should be both quantitative and qualitative dimensions involved in this measurement process. The quantitative measures of training performance typically include items such as the number of people attending training, new courses developed, amount of money spent or the number of hours of training delivered. However, these quantitative measures of training usually provide only a very shallow evaluation directed primarily at determining the attendee's reaction to the training (Basarab & Root, 1992). Consequently, these measures are of little value to managers outside the training and HRM departments (Phillips, 1998b). Qualitative measures,

on the other hand, involve more in-depth analyses, such as measures of behavioral changes and results produced toward organizational objectives and the organizational mission.

Methodology

The population for this study included manufacturing companies with 50 or more employees in 14 northeast Alabama and 9 northwest Georgia counties. Companies in these counties were selected at random from the Alabama and Georgia Manufacturing Directories from within the manufacturing standard industrial classifications (SIC) (Battle & Prue, 1994; Alabama Development Office, 2000).

The lower limit for the size of the companies surveyed was set at 50 for several reasons. Since many of the companies in the region being studied were small, sole proprietor textile and job shop operations conducted out of the home, basement or garage, with perhaps two or three family members, it was decided that inclusion of these small establishments would unduly influence the data. Another important consideration for limiting the study to those companies with 50 or more employees was the fact that the Occupational Safety and Health Administration (OSHA) requires only those companies with 50 or more employees to keep formal illness and injury records. Since safety was an important part of this study the size of the companies surveyed was limited to those reporting 50 or more employees in the manufacturing directories.

Instrument Design

An advisory panel of experts was used to design the survey instrument. The advisory panel consisted of seven individuals currently working in the fields being studied, four from industry and three from academia. Care was taken to make sure experienced and competent people, expert in

each of the areas addressed in the instrument and high enough in the management hierarchy of their companies to have a broad grasp of production, quality, and safety matters, were used in the development of the instrument. The researcher coordinated and consolidated input from panel members.

After reviewing related literature in each of the areas being studied, a research questionnaire was formulated and tentative parameters for the study were established. Draft copies of the instrument proposed for the pilot study were sent to members of the advisory panel. Panel members reviewed the draft instrument for content validity, reliability, length, clarity and relevance. Panel members then returned the instrument to the researcher with their comments and recommendations. Their comments and recommendations were then consolidated, the instrument revised and sent back out to the panel members. This process was repeated through three iterations until the final preliminary instrument to be used in the pilot study was completed.

Peer Review

The pilot instrument, accompanied by a cover letter, was sent to top managers of thirteen manufacturing companies who were asked to answer and evaluate each question. They were asked to state whether they thought the question was valid, i.e., accurately addressed the issue at hand, and whether the question would be reliable from one company to another. They were also asked to state whether they agreed with the questions and to provide comments supporting their position. If they thought a question was not valid or reliable, in any way, they were asked to rewrite the question in a manner that would meet those criteria. Returned surveys from the pilot study were analyzed for disagreements and inconsistencies. The pilot instrument was revised and

then reviewed by the advisory panel. As a result, the final instrument consisted of 65 items and was utilized to gather information for the formal study.

Data Collection and Analysis

Companies that fit the established criteria were selected at random from the Alabama (1997/1998) and Georgia (1994/1995) Manufacturing Directories (Alabama Development Office, 2000; Battle & Prue, 1994). Two hundred and fifty companies were randomly selected to participate in this study and questionnaires were sent to the identified respondents. Once a company had been selected, a telephone call was made to the top manager of the establishment. These managers were advised of the purpose of the call, and asked if they would be willing to participate in the study. They were advised that their participation was strictly voluntary and that they could withdraw from the study at any time without prejudice. If they agreed to participate, they were mailed a packet containing the questionnaire, the cover letter and a self addressed stamped envelope. Two-hundred and fifty packets were mailed.

If no response had been received after two weeks, a follow-up call was made to ask if the package had been received and if there were any questions. After two additional weeks had passed, if no response had been received, a final call was made. If there was no response after this, the respondent's name was crossed off the list. Of the 250 packages sent out, 133 were returned. Of the 133 that were returned, 108 were usable, for a final return rate of 43%.

Responses were coded and entered into the computer using the 1998 version of Statistical Package for research in the Social Sciences (SPSS), version 8.0. Two methods of analysis, regression, and multi variate analysis (MANOVA) were employed in this study. Regression

analysis was used to answer the first research question and a multi-variate analysis (MANOVA) was used to answer the second.

Regression Analysis

Three dependent variables were identified in each of the categories studied, i.e. three from production, three from quality and three from safety, and seven independent variables were selected from the education and training category for the regression analysis. Dependent variables selected from production were return on investment, sales per employee, and inventory turnover rate. Dependent variables selected from quality were ISO certification, product reject rate at final inspection and customer return rate. Dependent variables selected from safety were illness/injury rate, lost workday rate, and number of workers compensation cases experienced. Data from each of these categories were regressed against the independent variables from the education and training category. Independent variables from education and training were: (a) dollars spent on education and training as a percent of sales; (b) portion of education and training dollars spent for academic education; (c) portion of education and training dollars that went for continuing education; (d) portion of education and training dollars spent each year on in house training; (e) hours spent in training per employee per year; (f) hour's employees spent each year on academic education; and (g) average hours of continuing education units each employee pursued each year.

Multivariate Analysis

A multi variate analysis (MANOVA) was conducted by comparing the means of dollars invested and time spent in education and training to company size to determine if there were any significant variations by company size. Two variables, number of employees and annual sales,

were considered to be most representative of company size. Data from these two variables were re-coded to categorize companies as small, medium or large and used as independent variables to be compared to the seven dependent variables chosen as being most representative of investment in education and training. These were the same seven variables previously used as independent variables in the regression analysis, but re-designated as dependent in the multi-variate analysis.

Results and Discussion

Company Specialty and Size

Respondent company specialties were distributed as shown in Table 1. Two variables were selected from the company's general information as appropriately representing company size. These were number of employees and annual sales. Company size was collapsed into three categories of small, medium, and large. The small category included companies with 50 to 99 employees; medium-size companies were those with 100 to 225 employees and large companies were those employing between 226 and 1,200 employees (Table 2). Annual sales was also re-coded into categories as low, medium or high, with low representing those companies with annual sales between $0.45 million and $14 million, medium representing those companies with sales between $15 million and $34 million and high representing those companies with sales between $35 and $180 million (Table 2).

Table 1

Type of Manufacturing Operation of Participating Companies

Specialty	Number of responses	Percentage*
Food & Beverage	17	15.7
Clothing, Leather, & Textiles	20	18.5
Lumber, Paper & Wood Products	13	12.0
Petrochemicals, Plastics & Non-Metallic Minerals	10	9.3
Metal Production	23	21.3
Miscellaneous Manufacturing‡	25	23.2
Totals	108	100%

* Percentages calculated as 100×N/108

‡ As the software used in the multivariate analysis was unable to cope with categories containing fewer than two cases, the smaller groups were combined into larger categories. "Paper and Printing" and "Furniture" were included in "Lumber, Paper and Wood Products," while other small categories such as "Electrical and Electronics" and "Transportation Products" were placed in "Miscellaneous Manufacturing." Eight companies could not be identified with any of the separate categories, and were also included in the "Miscellaneous" category.

Table 2.

Company Size in Terms of Number of Employees and Annual Sales

Number of Employees	Frequency	Percentage
Small (50-99)	27	26.5
Medium (100-125)	41	40.2
Large (226-1200)	34	33.3
Totals	102	100
Annual Sales ($Millions)	Frequency	Percentage
High (35-180)	27	32.9
Medium (15-34)	28	34.2
Low (0.45-14)	27	32.9
Totals	82	100

The regression analysis looked at performance in each of the three categories studied, i.e., production, quality, and safety, using regression analysis with a backward process of elimination method in each case, eliminating one variable at a time to determine whether there were any relationships among the selected variables at the .05-level. An analysis of production examined the relationship between the independent variables representing education and training, and three dependent variables, sales per employee, inventory turnover, and return on investment. The analysis of quality examined the relationship between seven independent variables from education and training and ISO 9000-certification, reject rate at final inspection, and the customer return rate. The analysis of safety looked at the relationship between the seven independent variables

from education and training and illness/injury rate, lost workday rate, and number of workers compensation cases.

Regression Results

The overall regression model for production showed no significant relationships ($p \leq .05$) between the independent and dependent variables. Consequently, no restricted model was determined for production (Table 3). For the quality regression, a restricted model ($p = .019 < .05$) was determined for the relationship between ISO 9000 certification and the amount of in-house training each employee received (Beta = .359) and the average amount of academic education each employee received per year (Beta = .364). Together these two variables accounted for 23.3% of the variance for the ISO 9000 certification quality performance indicator. The difference between the amount of variance explained by the restricted model (23.3%) and the overall model (31.3%) was not statistically significant, therefore the more parsimonious restricted model was used (Table 3). For safety, the overall model for safety showed no significant relationships between the seven independent variables from education and training and two of the three dependent variables from safety. However, there was a significant relationship ($p < .027 < .05$) between the lost workday (LWD) rate and (a) the amount of in-house training and, (b) the portion of education and training dollars expended for continuing education units (CEUs). The restricted model showed that 27.6% of the variance between the LWD rate safety performance indicator and the overall model could be explained by these three variables (Table 3).

Table 3

Results of the Regression Analysis

All values are given for the overall model unless otherwise specified.

	No. of dependent variables	R^2	F	Significance
Production				
Sales/employee	7	.251	1.052	.425
Return on investment	7	.480	0.522	.808
Average inventory turnover rate	7	23.0	0.809	.590
Quality				
ISO 9000 certification rate	7	.313	1.630	.173
[restricted model*	2	.233	4.565	.019]
Rejection rate	7	.228	0.760	.627
Customer return rate	7	.305	1.068	.424
Safety				
Illness/injury rate	7	.205	0.919	.509
Lost workday rate	7	.339	1.757	.143
[restricted model‡	3	.276	3.554	.027]
Workers compensation cases	7	.160	0.515	.812

* For dollars spent on in-house training, Beta = .359, and for hours spent in academic education per employee per year, Beta = .364.

‡ For training vs. sales, Beta = -.340, dollars spent on CEUs, Beta = -.306, and for dollars spent on in-house training, Beta = .431.

Multivariate Analysis

A multivariate analysis was conducted to determine the relationship between company size (i.e., small, medium, and large) as represented by the number of employees and annual sales figures, and the dependent variables from education and training. A multi-variate correlation was conducted on each of these predictor variables independently. Neither company size in terms of the number of employees (Wilks Lambda = .470, P = .399) nor company size as represented by annual sales (Wilks Lambda = .621, P = .800) showed a significant relationship to investment in education and training.

Multivariate analyses were also conducted to determine whether company specialty made any difference in investment in education and training and performance in production, quality or safety. Specialties were re-coded, designated as the independent variable and multi-variate analyses conducted of (a) company specialty versus investment in education and training, and (b) company specialty versus three dependent variables each from production, quality and safety.

Dependent variables from production were sales per employee; inventory turnover rate; and return on investment; from quality, ISO 9000 certification, final inspection reject rate, and customer return rate; and from safety, illness/injury rate, lost workday rate, and number of workers compensation cases. The multi-variate analyses revealed no significant relationships between company specialty and either investment in education and training (Wilks Lambda = 0.182; p = 0.412) or performance in production (Wilks Lambda = 0.602, P = 0.493), quality (Wilks Lambda = 0.696, P = 0.288), or safety (Wilks Lambda = 0.783, P = 0.434).

Conclusions and Recommendations

Although no firm conclusions could be drawn from the data collected for this study, several valuable conclusions did emerge from the process. The study appears to support suggestions in the literature that industrial managers and training professionals need a better understanding of the connection between education and training and the bottom line. One of the conclusions drawn was that the value of the process of conducting this study was at least as important as the product it produced.

Valuable lessons were learned that should be applied in any future studies in the area of evaluating the costs and benefits of investment in education and training. First among the lessons learned was the need for a clearly defined research objective. The research objectives for this study were too numerous and broad, including the study of the somewhat diverse fields of production, quality and safety. Although these three functions are closely united and coordinated in an effective and efficient manufacturing establishment, the knowledge base of each represents a complex and diverse discipline. The objectives of the study were further diffused by the inclusion of both education and training which, although they are related, are different in purpose, context, approach, and method.

Another lesson to be learned was that the individual to whom the instrument is sent should be clearly identified as working within the field in which the research is to be conducted. This should reduce the amount of research required, improve spontaneity on the part of the respondent, and result in more complete and accurate answers. The study enabled the researcher to conclude that there is a need for additional research in the whole area upon which this study

was based, i.e., the relationship between investment in education and training and performance in production, quality and safety, albeit not all in the same study. In particular, the relationship between training and return on investment (ROI) merits further investigation. Evaluating education and training in terms of ROI is an idea whose time has come. Empirical research is needed to bear this out and to pave the way for this worthwhile transition (Phillips, 1998b). This effort should be undertaken by researchers in academia, since the primary focus of industry is in producing goods for a profit.

The literature review conducted as part of the study showed there has so far been little systematic effort in either the manufacturing industry or in academia to generate and gather empirical evidence concerning the veracity of the evaluation process and the contribution of education and training to the financial bottom line in manufacturing companies. This may be due to a lack of understanding and appreciation for the contribution of education and training to business success among industrial managers and training practitioners. The literature confirmed a growing demand in the manufacturing industry for financial accountability for training practitioners to enable them to show in terms of dollars and hard data exactly what education and training contribute to return on investment. Future studies should be careful to clearly define and specify exactly what is to be studied, and narrowly focused when framing the research questions. The instrument to be used should be very clear and limited in the number of questions posed. These questions should be focused in the one area to be studied and the respondent should be limited to the area of his or her expertise.

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the whole area upon which this study was based, i.e., the relationship between investment in education and training and performance in production, quality and safety, albeit not all in the same study. In particular, the relationship between training and return on investment (ROI) merits further investigation. Evaluating education and training in terms of ROI is an idea whose time has come. Empirical research is needed to bear this out and to pave the way for this worthwhile transition (Phillips, 1998b). This effort should be undertaken by researchers in academia, since the primary focus of industry is in producing goods for a profit.

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